GUIDE TO

THIRTY-SEVENTH ANNUAL FIELD CONFERENCE

OF THE

SECTION OF GEOLOGY

OF THE

OHIO ACADEMY OF SCIENCE

May 5, 1962

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GEOLOGY OF THE TOLEDO AREA

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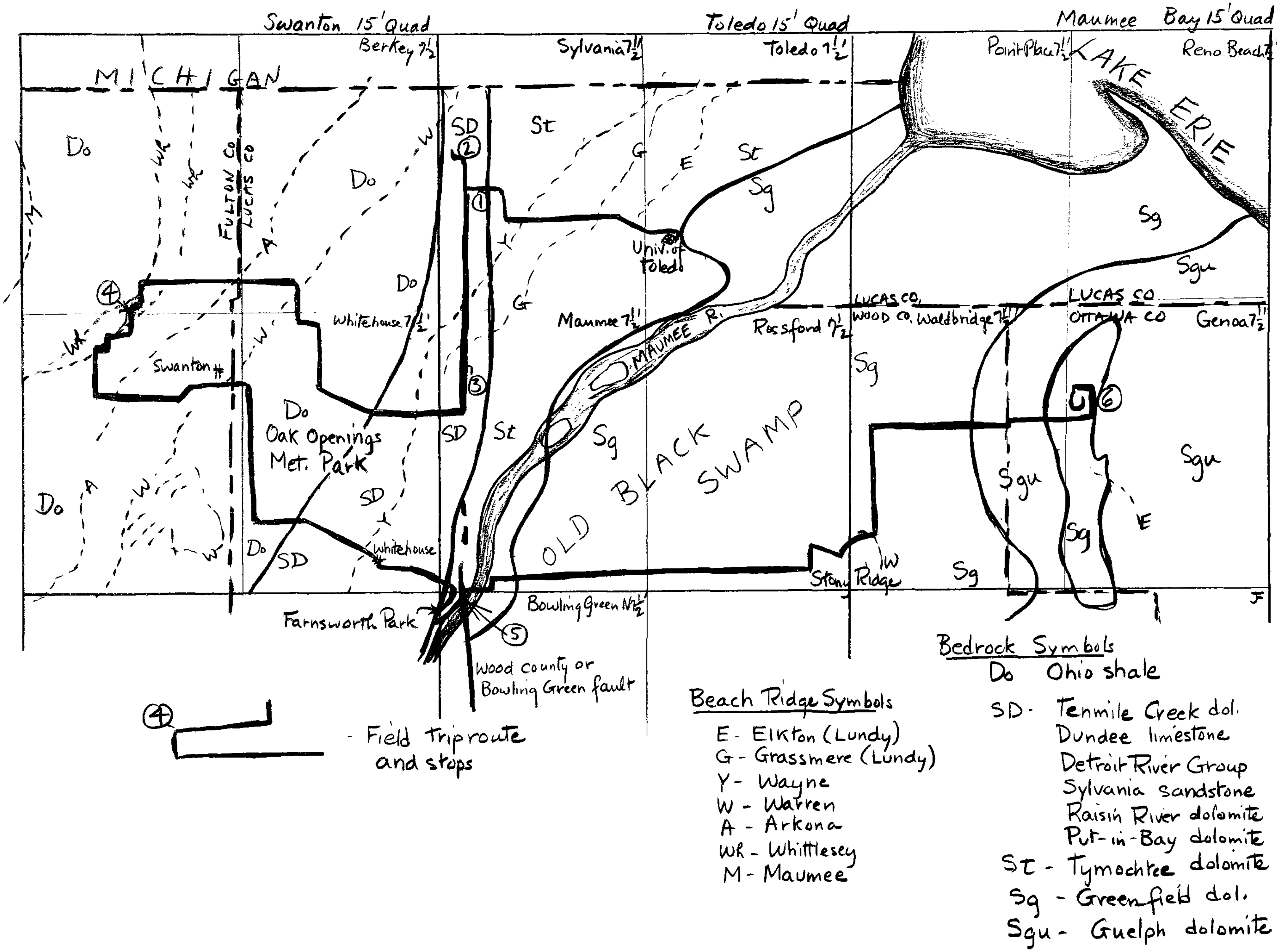
Lucas County, in which most of this trip lies, belongs to only one person, Dr. J. Ernest Carman. For many years he has labored to unravel the geological story here. In 1948 he led a two-day Ohio Academy field trip into this area that many of us who have come to Ohio more recently wish we could have attended. And, for years, he has led the students of his famous course in the geology of Ohio into this area. It is from these two sources that all the information in this field trip guide originates; without the data supplied from earlier field trip or from class notes, this guidebook could not have been written. As a result, in recognition of his tremendous contribution to the geology of Lucas County, and of all Ohio, this guidebook is humbly dedicated to Dr. J. Ernest Carman.


Swanton 15' Quad
Toledo 15' Quad
Maumee Bay 15' Quad
Berkey 7½'
Sylvania 7½'
Toledo 7½'
Point Place 7½'
Reno Beach 7½'
LAKE ERIE
MICHIGAN
FULTON CO
LUCAS CO
Do
SD
St
Sg
Sgu
Univ. of Toledo
Whitehouse 7½'
Maumee 7½'
MAUMEE R.
Rossford 7½'
LUCAS CO.
WOOD CO.
Walbridge 7½'
LUCAS CO
OTTAWA CO
Genoa 7½'
Swanton
Oak Openings Met. Park
Whitehouse
Farnsworth Park
OLD BLACK SWAMP
Bowling Green N 7½'
Stony Ridge
Wood county or Bowling Green fault
Field trip route and stops
Beach Ridge Symbols
E - Elkton (Lundy)
G - Grassmere (Lundy)
Y - Wayne
W - Warren
A - Arkona
WR - Whittlesey
M - Maumee
Bedrock Symbols
Do Ohio shale
SD - Tenmile Creek dol.
Dundee limestone
Detroit River Group
Sylvania sandstone
Raisin River dolomite
Put-in-Bay dolomite
St - Tymochtee dolomite
Sg - Greenfield dol.
Sgu - Guelph dolomite

GEOLOGY OF THE TOLEDO AREA

Assembly - 7:45 A.M. in the University of Toledo parking lot. Extra guidebooks and topographic maps will be available at this time. Group will leave lot promptly at 8:00 A.M.

Drivers - Please mark your cars with the paper markers provided. On the road, please stay in line and drive carefully; many of the roads we will be on or will cross are busy main highways. Because the route between the assembly point and the first stop is in the city, it will be difficult for us to stay together as a group; therefore, the lead car will simply proceed to the first stop, following the route in the guidebook, and each driver will be responsible for also following the directions in the log to the first stop. In the last quarry of the day, at Clay Center, our driving must be restricted to main quarry roads; to avoid difficulty, please drive only along route established by lead car.

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Mileage		
Individual	Total	Road log
0.0	0.0	Leave University of Toledo parking lot, turning left (west) onto Bancroft Street. Route lies on lake bottom below lowest, Elkton (Lake Lundy) beach.
0.5	0.5	5-way intersection. Turn diagonally far right (northwest) off Bancroft Street onto Indian Road.
0.7	1.2	Low sand hills here, best seen to the right (north) are part of the low Elkton beach (L. Lundy) which represents the lowest pre-modern level of Lake Erie (at 615' elevation; Lake Erie's present elevation is 573').
1.1	2.3	Turn diagonally left (west) off Indian Road onto Central Avenue.
0.5	2.8	Cross Tenmile Creek. Low bumps to right (north), west of creek valley, are part of the Grassmere beach (640' elevation) of Lake Lundy, the first and highest of the three Lundy lake levels (Grassmere, Dana, Elkton).
0.6	3.4	Go under New York Central Railroad tracks.
		Traffic light. At junction with Holland Road(and US 20) from the right, continue straight ahead (west) on Central Avenue which becomes US 20. The main line of the Grassmere beach crosses this intersection diagonally from northeast to southwest, but this low beach is almost lost in the maze of streets and buildings here.
0.9	4.3	Slight detour around construction of overpass to go over new US 23 Expressway from Sylvania to Central Avenue (scheduled to be completed by Sept. 1, 1962).
0.7	5.0	Intersection of Central Avenue (US 20) and McCord Street. Continue straight ahead (west) on Central Avenue.
0.6	5.6	Note sand hills which form a line crossing Central Avenue diagonally from northeast to southwest. A third of a mile ahead on the right (north) a pit exposes loose oxidized quartz sand which is more than six feet thick. This is the Wayne beach (660' elevation) which, though more prominent than any of the Lake Lundy beaches, was lowered after its formation and smoothed by being submerged, due to readvance of the ice, so that the Wayne lake outlet to the east through the Mohawk River valley was blocked and the waters of the resulting higher lake (Warren, at 680') had to spill out to the west, through the Grand River outlet in central Michigan. The entire sequence of lakes is shown in the accompanying chart on the next page. Despite the fact that the Wayne beach was submerged after being formed, it is characterized by some fairly distinct hills; there are dunes, probably blown into shape after the Wayne beach was again emergent. The entire area west of Toledo and north of the Maumee River (including western Lucas County and the eastern part of Fulton County) is characterized by broad expanses of sand and by sand dunes. The dunes generally lie along the beaches (Elkton up to Whittlesey), but sand also forms an almost continuous blanket between these beaches. Low exposures along the road, in excavated areas near buildings, and in natural blowouts are common throughout this area, as may be seen at many places along this route. Why the sand is so abundant here, particularly in the areas between the beaches, is not understood. As a result of this dry, sandy, acid soil, this area is characterized by an unusual association

Age	Lake	Beach	Elevation	Reason for change
	Erie	modern	573	Isostatic uplift to north
		Algonquin	535?	Continued ice retreat
Recent	Lundy	Elkton	615	Erosion of outlet (continued ice retreat)
(11,500-		Dana	620	Erosion of outlet (continued ice retreat)
present)		Grassmere	640	Retreat of ice
	Warren		680	Readvance of ice
	Wayne		660	Retreat of ice
	Whittlesey		735	Readvance of ice
Wisconsin	Arkona		710	Retreat of ice
(Mankato)	Maumee III		780	Readvance of ice
	Maumee II		760	Continued retreat of ice
	Maumee I (only in western lake basin)		800	Formation of first major depression between ice and state drainage divide

Figure 2. Chart of Major Glacial Lakes in Lake Erie Basin

of plants which is not duplicated anywhere else in Ohio. Most of the trees are oaks which occur in open stands. In addition, raspberries and blackberries are common, as well as many dry prairie plants, relicts of a period about 5000? years ago when, because of a dryer climate, many western prairie-type plants invaded Ohio. This area is called the Oak Openings (see Fig. 10). A small area (3200 acres) of this Oak Openings region has been set aside as a park by the Toledo Metropolitan Park Board. Our route will lead around the edge of this park, near Whitehouse, just before lunch.

0.4 6.0 Turn right (north) off Central Avenue (US 20) onto King Road. Road cuts diagonally through sand hills and dunes of Wayne beach. Note old sand diggings (now a dump) to left two-tenths of a mile north of the intersection and the characteristic vegetation of these sand hills - oaks in open stands.

1.0 7.0 Turn left (west) onto Sylvania Avenue from King Road by small pits in Wayne beach sand.

0.6 7.6 Cross Tenmile Creek.

0.2 7.8 Pull over on right berm, parking cars well of road and close together.

STOP 1. An abandoned quarry of the Toledo Stone and Glass Sand Company (France Stone Company).
Location: 2 1/2 miles southwest of Sylvania ; NW 1/4 of NW 1/4 of Sec. 20, T9S, R6E, Sylvania Twp. Lucas County.

The section exposed in this long-abandoned quarry is:

Unit	Thickness in feet
Devonian System	
Detroit River Group	
Anderdon dolomite	35
Lucas dolomite	73
Amherstburg arenaceous dolomite	18
Sylvania sandstone	10+

The Detroit River Group, named for exposures along the Detroit River to the north, is characteristically represented in northwestern Ohio by the Lucas dolomite, which has been divided into nine zones on the basis of color variations, thickness of beds, and the local presence of abundant calcite. A separate upper unit of dense limy dolomite with a slightly different fauna is called the Anderdon. The underlying Amherstburg arenaceous dolomite, in its type area in Canada, is a dolomite which lacks the sand found here and has a characteristic fauna. In Lucas County, however, because the Devonian sea reached this area only in late Amherstburg time, the Amherstburg dolomite contains sand from the underlying Sylvania sandstone, thus forming a transition unit between the sandstone and the overlying Detroit River dolomite. The Detroit River Group is also present on the east side of the Findlay arch (the northern branch of the Cincinnati arch), being present in the channel between Kelleys Island and the Bass Islands, on Marblehead Peninsula, and west of Bellevue; it is not recognized south of this point.

Figure 3.

Bedrock Stratigraphy of Northwestern Ohio

All data copied from Dr. J. Ernest Carman,
from the 1948 OAS Guidebook and from OSU class notes

System	Units	Thickness in feet	To be seen at stops	Description
DEVONIAN	Senecan			
	Ohio Shale	100	-	Recognized half a mile west of Silica quarry from well data.
	Erian			
	Tenmile Creek dolomite	40	-	Shaly dolomite occurring south of Silica quarry along Tenmile Creek and identified in well records to the west.
	Silica formation	51	2	Alternating units of blue argillaceous limestone and blue shale, both fossiliferous, the basal units being extremely fossiliferous, many fossils being pyritized. Fossils include: Aulopora, Cystiphyllum, Heliophyllum, Zaphrentis, Arthracantha, Fenestella, Hederella, Atrypa, Chonetes, Cyrtina, Rhipidomella, Spirifer, Stropheodonta, Pterinea, Platyceras, Phacops.
	Dundee limestone	55	2	Limestone composed of an upper 15-foot unit of gray crystalline, very fossiliferous limestone over a lower 40-foot unit of thick-bedded, slightly fossiliferous dolomitic limestone. Fossils include: Prismatophyllum, Favosites, Paracyclas, Conocardium, Atrypa, Cyrtina, Productella, Stropheodonta.
	Ulsterian			
	Detroit River Group			
	Anderdon dolomite	35	1	Dense limy dolomite with fauna similar to, but slightly different from that in Lucas dolomite (containing abundant stromatoporids)
	Lucas dolomite	74	1	Drab dolomite in 3-12-inch layers, but at places with thicker, rougher-textured layers, moderately fossiliferous. Fossils include: Prosserella, Cylindrohelium, Acanthonema, Holopea, Hormotoma, Conocardium.
	Amherstburg	15	1	Beds here are transitional here (no true Amherstburg dolomite is present), being those basal Detroit River dolomite strata which contain sand.
	Sylvania sandstone	25	1, 3	Sandstone composed of even-sized, well-rounded, quartz grains, some of which are frosted; believed to be eolian sand reworked by transgressive Devonian sea.
				D I S C O N F O R M I T Y
SILURIAN	Cayugan			
	Bass Islands Group			
	Raisin River dolomite	50	3	Blue-gray to drab, mottled, laminated, and locally brecciated dolomite in beds 2-8 inches thick, sometimes in thicker beds. Fossils include: Whitfieldella, Pterinea, Spirorbis.
	Put-in-Bay	35	3	Dark, drab, massive dolomite, brecciated in many places. Fossils include: Eurypteris, Goniophora, Leperditia, Spirifer.
	Tymochtee shaly dolomite	250±	5	Brown thin-bedded shaly dolomite with much carbonaceous material occurring as partings, generally unfossiliferous.
	Greenfield	50	6a	Drab compact fine-grained dolomite with some fossils. Fossils include: Hindella, Camarotoechia, Schuchertella, Leperditia.
				D I S C O N F O R M I T Y
	Niagaran			
	Guelph dolomite	100+	6b	Light blue-gray porous sugary to crystalline fossiliferous dolomite with crystals of selenite, barite, and fluorite. Fossils include: Stromatopora, Favosites, Halysites, Syringopor, Trimerella, Megalomus, Euomphalus, Tremanotus.

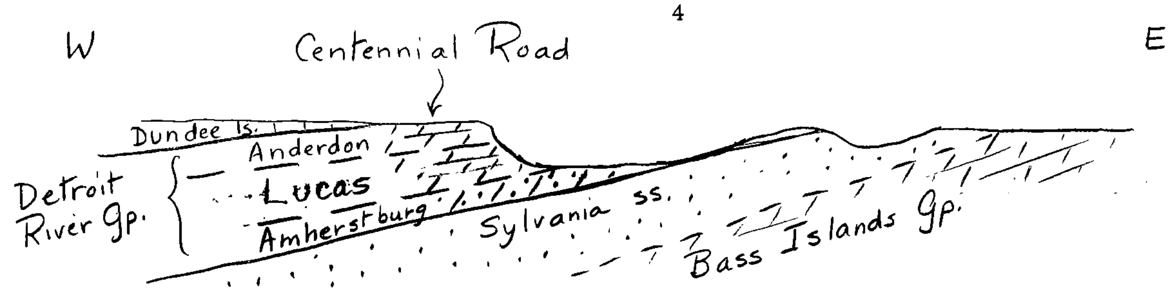


Figure 4. Diagrammatic Cross Section at Stop 1

The Sylvania sandstone is composed of well-rounded, uniformed-sized, frosted grains of quartz, whose arrangement shows cross-bedding in places. It is considered to be eolian in origin, the sand being reworked by the advancing Devonian sea, as evidenced by the presence of horizontal bedding in places and of some Detroit River fossils. Because the Devonian sea was transgressive, the age of the oldest Devonian marine rocks in different places in Ohio varies. Since it was this same transgressive sea which reworked the sand, the age assigned to the sandstone also varies (Fig. 5).

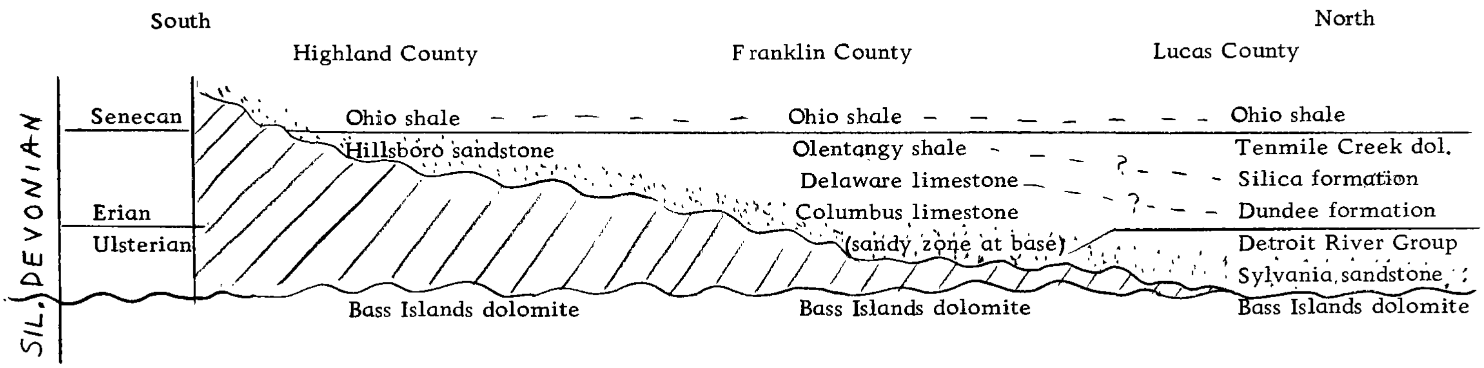


Figure 5. Diagrammatic Representation of Transgression of Devonian Sea across Ohio

In the Toledo area, the Devonian sea came in during early Devonian (Ulsterian) time, as indicated by the age of the earliest Devonian marine units (Detroit River Group), so the Sylvania sandstone here is also Ulsterian in age. In the Columbus area, however, the Detroit River Group is lacking and the basal Devonian marine unit is the Columbus limestone. No true sandstone occurs there, but at the base of the Columbus limestone is a thin conglomeratic zone which contains a significant proportion of well-rounded, even-sized, frosted quartz sand grains; ths sand in this zone is also believed to represent eolian sand grains reworked by the advancing Devonian sea, making this zone essentially a Sylvanian equivalent which here is of Er ian (Middle Devonian) age, rather than Ulsterian age. Still farther south, in Highland County (see paper by Carman and Schillhahn in Jour. of Geol. for 1930, p. 246), all the Erian strata, including the Columbus limestone, are lacking and the basal Devonian unit is the Ohio shale of Senecan age. Beneath the shale is the Hillsboro sandstone, which is underlain directly by Silurian dolomite (actually, the sandstone is not only a sedimentary unit between the shale and dolomite here, but also fills pockets in the dolomite, believed by Carman and Schillhahn to have been dissolved out during the interval before the Devonian sea reached this area). This Hillsboro sandstone, since it is also composed of well-rounded, even-sized, frosted grains of quartz, is also considered to be a Sylvania equivalent, here of late Devonian, or Senecan age.

The reason why the Sylvania sandstone and the various units of the Detroit River Group all crop out so close together in the Toledo Stone and Glass Sand Company quarry is that they lie along a belt of gentle but significant dip (6-7 degrees) to the west. In Ohio's land of essentially flat strata, these are steep dips! This also explains why the overlying Dundee and Silica formations, to be seen at the next stop, are exposed immediately to the west. This area lies on the axis of a north-south structure known as the Lucas County monocline. To the south, the Holland quarry of the France Stone Company, Stop 3 of this trip, also lies on this structure. Followed still farther south, to near Waterville and the Maumee River, the monocline becomes a steep-angled fault with a throw of about 200 feet at the maximum, called by some the Wood County fault and by others the Bowling Green fault. This fault will be seen at Stop 5.

		Continue straight ahead (west) on Sylvania Avenue.
0.2	8.0	Turn right (north) off Sylvania Avenue onto Centennial Road. In the quarry to the right, formations of the Detroit River Group crop out, overlain by Dundee limestone. In the quarry on the left, Dundee limestone forms the cliff next to the road, but as it dips down to the west, it is overlain by the Silica formation. A good view into both pits is provided where a tunnel connecting the two pits underlies Centennial Road, two-tenths of a mile north of the Centennial-Sylvania intersection.
1.0	9.0	Turn left (west) off Centennial Road onto Brint Road.
0.2	9.2	Follow lead car in parking cars.

STOP 2. Medusa Portland Cement Company Quarry.

Location: 2 miles southwest of Sylvania; SE 1/4 of SE 1/4 of Sec. 7, T9S, R6E, Sylvania Twp., Lucas Co.

The main formation exposed in this pit is the Silica formation, although the very top of the underlying Dundee limestone may also be visible (quarrying operations continually change the exposure). The Silica formation has been divided into the following broad lithologic units:

Unit	Thickness in feet
E. Blue argillaceous limestone	8
D. Blue shale	20
C. Blue argillaceous limestone, becoming shaly at top	4
B. Blue fossiliferous calcareous shale, which is soft and easily disintegrated, with some shaly limestone layers, especially in the upper part (this is the Silica Shale)	11
A. Blue fossiliferous limestone, finely crystalline near base, becoming shaly near top	8

Both Units A and B are highly fossiliferous. Unit B, the famous "Silica Shale", has been studied in detail by Dr. Grace Anne Stewart (1927). She reports the following genera as common:

Corals:	Aulopora, Cystiphyllum, Heliophyllum, Zaphrentis	Brachiopods (most important group, especially in upper part of Unit B)	Atrypa, Chonetes, Rhipidomella, Spirifer, Stropheodonta
Worms:	Spirorbis		
Bryozoa (second most important group; most abundant in lower strata, of Unit B)	Cystodictya, Hederella, Reptaria, Streblotrypa, Botryllopora, Acanthoclema	Pelecypods	Pterinea
		Gastropods	Platyceras
		Trilobite	Phacops

The shale also contains iron sulfide, identified by Dr. Stewart as marcasite, which occurs as concretions and as a replacement of shells of fossils. Dr. Stewart notes that the blue limestone, Unit A, is also rich in fossils, mentioning especially the genera: Spirifer, Stropheodonta, Chonetes, and Rhipidomella.

A study of the ecology of the Silica formation as a whole from the detailed lithologies and the fossils has been done by David G. Nussman in a master's thesis for the University of Michigan(1961, unpublished). The following material has been taken from material supplied by him (correlation of Nussman's descriptions with above units by Forsyth):

Unit A (called by Nussman, Bioclastic Limestone Biotope) represents "the classic warm, shallow-water, wave-agitated environment with relatively firm substrate" which "supported a prolific coral-brachiopod community".

Unit B, in its lower part is composed of shale with zones of shaly limestone(Nussman's Cryptostomate-Crinoidal Argillaceous Limestone Biotope) which " are characterized by crinoidal debris and an overwhelming prodominance of cryptostomate Bryozoa of 'twig'.....and 'frond'..... growth forms". These shaly limestone layers represent the "transition from the shale to the Argillaceous Limestone Biotope, where the influx of terrigenous mud has suddenly decreased". The upper part of Unit B (Nussman's Argillaceous Limestone Biotope) "is characterized by cancaveo-convex brachiopods and a abundance of Bryozoa of massive encrusting and heavy, irregularly ramose growth forms". "Also present in this biotope are more fragile bryozoan species, crinoids, and plant remains ('fucoids')." "The shallow waters, turbid during storms but relatively clear most of the time, probably were of normal salinity and oxygen content". Iron sulfide, present in concretions and in shell replacements,

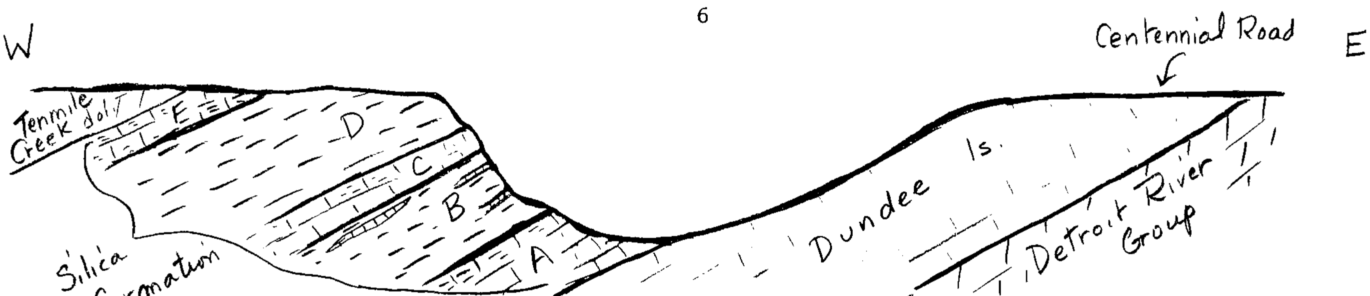


Figure 6. Diagrammatic Cross Section at Stop 2.

is reported by Nussman to be"pyrite, rather than marcasite". "Individual taxomonic groups show different degrees of pyritization. Field Evidence and correlation with modern environments suggests that the pyritization was an early diagenetic feature, taking place just below a normally aerated substrate. Formation of pyrite is the result of the incorporation of considerable organic matter in the sediment and concomitant growth of heterotrophic sulfate-reducing bacteria, availability of iron, and continuous supply of sulfate from the waters above; hence removal of ferrous iron and sulfide by precipitation of iron sulfide predominated over removal by ionic diffusion and mass transfer upward into the aerobic zone with subsequent oxidation."

Unit C - is apparently included in this Argillaceous Limestone Biotope of the upper part of Unit B.

Unit D (called by Nussman the Calcareous Shale Biotope) "is characterized by dark gray, carbonaceous, calcareous shales". "Wave sorting probably occurred close to the substrate", making the reducing conditions so pronounced that the unit is "virtually devoid of benthonic fauna".

Unit E is interpreted by Mussman to be also an Argillaceous Limestone Biotope, like the upper part of Unit B, though the same abundanace of fossils is not necessarily indicated.

Follow lead car around and back to Centennial-Brint Road intersection. Turn right (south) on Centennial Road and continue south for about 5 miles.

1.4 10.6 Cross bumpy railroad crossing of Toledo Stone and Glass Sand Company (France Stone Company).

0.4 11.0 Cross Tenmile Creek. The Tenmile Creek dolomite, which overlies the Silica formation has been exposed along this creek, half a mile back to the west (right) at one time.

0.4 11.4 Stop. Continue straight ahead (south) across US 20 (Central Avenue).

0.6 12.0 Low sand hills are dunes of the Wayne beach.

0.4 12.4 Stop. Continue straight head (south) across Bancroft Street.

0.3 12.7 Bear right and then go straight ahead (south) across Dorr Street. Low hills of sand (Wayne dunes) on left are used for growing grapes; similar sandy soils support grapes along the south side of Lake Erie, especially east of Cleveland , in Pennsylvania, and in western New York.

1.5 14.2 Sand hills to left (east) are Wayne dunes. Note oak vegetation; this is the type of vegetation characteristically found in the Oak Openings area.

0.5 14.7 Turn left (east) off Centennial Road onto Angola Road and then, almost immediately, turn right (south, again) onto Albon Road. Back to left, but not visible from intersection, is a sand pit in Wayne dunes, marked by the roadside sign "Ohio Sand Pit".

0.9 15.6 Seaway Sand Pit lies to right (west) in eolian sand, which is probably of Grassmere age since the main beach position lies just ahead, near the railroad crossing (very bumpy).

0.3 15.9 Stop. Intersection of Albon Road and Chicacgo Pike (Ohio route 2); continue straight ahead (south). The Grassmere beach, marked by very low dunes, crosses this intersection, oriented northeast-southwest.

1.4 17.3 Go under Ohio Turnpike.

0.2 17.5 Turn left (east) on old road to abandoned Holland Stone Quarry of France Stone Company.

STOP 3. Holland Stone quarry of France Stone Company.

Location: 2 miles southwest of Holland; NW 1/4 of SE 1/4 of Sec. 29, T2, Monclova Twp., Lucas Co.

Like the quarries visited near Sylvania, the Holland quarry lies on axis of the Lucas County monocline, as shown in Figure 11. The following stratigraphic section is exposed in this quarry:

Unit	Thickness in feet
Devonian System	
Detroit River Group	
Amherstburg arenaceous dolomite	5+
Sylvania sandstone	25
D I S C O N F O R M I T Y	
Bass Islands Group	
Raisin River dolomite	53
Put-in-Bay dolomite	35
Tymochtee shaly dolomite	20+

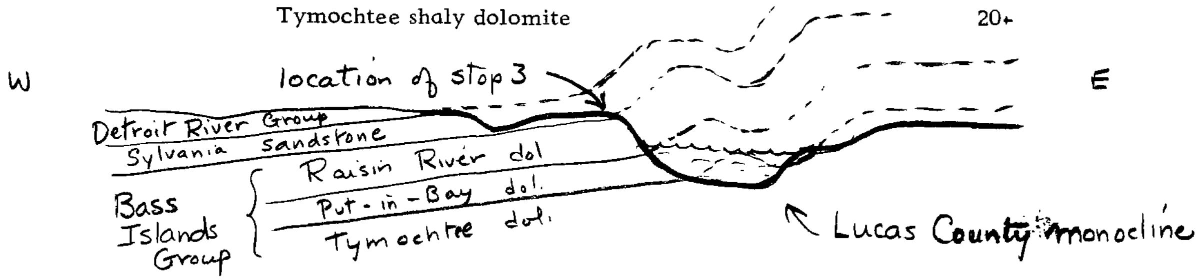


Figure 7. Diagrammatic Cross Section at Stop 3.

Only the Sylvania sandstone and Raisin River dolomite will be seen where the group will be, on the west bank of the quarry (time does not allow the group to go to the east bank also). On the west bank, in places, the disconformity between the sandstone and underlying dolomite may be seen in horizontal section, which cuts more or less horizontally through the disconformity surface. As a result, local thin masses of sandstone may be observed, lying on dolomite and with dolomite at the surface between these sandstone masses, which represents the truncated remains of the basal part of the overlying sandstone, as shown in Figure 8.

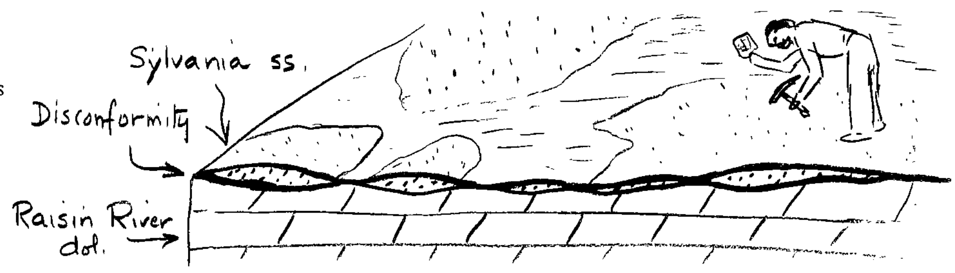


Figure 8. Sketch to illustrate View of Silurian-Devonian contact as observed on the west bank of Holland quarry.

Retrace route to Albon Road.

1.0	18.5	Turn left (south) on Albon Road
0.4	18.9	Continue straight ahead (south) across Salisbury Road On Albon Road. Low sand hills ahead to right (southwest) are Grassmere dunes.
0.5	19.4	Stop. Turn right (west) onto US 20 Alt. (very busy highway). For the next mile or so, road crosses the Grassmere beach and dunes diagonally, the orientation of the beach here being northeast-southwest.
2.4	21.8	Low sand hills to right (north) are Wayne dunes.
1.3	23.1	Dunes to left with small pits in them are probably related to the Warren beach.
1.0	24.1	Turn right (north) off US 20 Alt. onto Ohio route 295, To right is Toledo Express Airport, the main airport for Toledo.
0.4	24.5	Stop at busy intersection. Continue straight ahead (north) on Ohio route 295 across heavily travelled Ohio route 2. At intersection, field trip route crosses low rises of Warren beach, the beach being oriented almost east-west here.
0.8	25.3	Pass under Ohio Turnpike.
1.0	26.3	Swing left (west) following Ohio route 295 onto road called Old State Line Road, so called because it was the original Michigan-Ohio state line. Shortly after it was established, however, there was a big fight between the two states as to where the line should really be and who should own Toledo and the strategic Maume River. This fight, called the

"Toledo War" (1835), involved honest-to-goodness bloody fighting, but Ohio finally "won" the "war" by getting the US congress, in 1836, to officially move the state line north, in exchange for promising Andrew Jackson the electoral votes of Ohio, so Toledo became part of Ohio and this old state line became obsolete.

0.6 26.9 Swing back right (north) following Ohio route 295 off Old State Line Road.

0.6 27.5 Ridge off to left (west) is Warren beach which is oriented northeast-southwest and which passes diagonally under our road at Sharples Church just ahead.

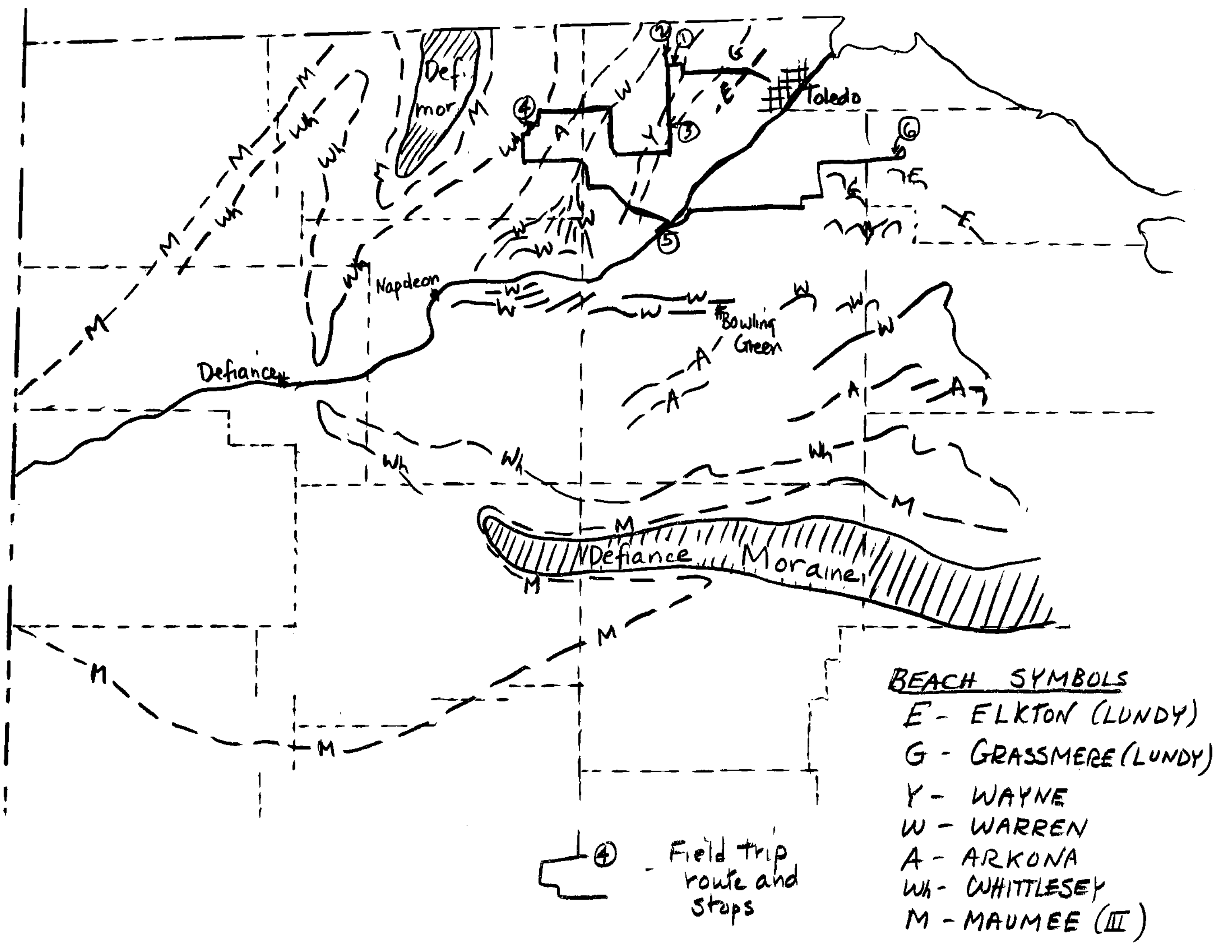
0.2 27.7 Turn left (west) onto Angola Road at intersection called Barnes Corners or Sharples, leaving Ohio route 295.

1.9 28.6 Road climbs broad low rise, which is oriented northeast-southwest. This is the Arkona beach, which after deposition, was submerged when the ice readvanced to create the following Whittlesey lake level (see Figs. 2 and 9).

0.3 28.9 Stop. Continue straight ahead (west) across Fulton-Lucas County line road. Note flatness of land (Whittlesey lake bottom) here.

2.7 31.6 That "mountain" up ahead is the Whittlesey beach, which here is oriented almost north-south. The Whittlesey beach in northwestern Ohio is in the shape of two V-shaped patterns, the more northerly "V" being rightside-up and the one farther south being upside-down (see Fig. 9). Together they mark the level of Lake Whittlesey

Figure 9. Generalized map of beach ridges of northwestern Ohio.



around the Defiance moraine which bends around the western part of the Lake Erie basin. The two "V's" almost meet at the town of Defiance, where the moraine had been breached by outlet waters from a pre-Whittlesey lake escaping to the west. Drainage from this earlier lake flowed west, up the Maumee River valley and across a divide in Indiana to the Wabash River and the Mississippi River system. The beach seen ahead is part of the eastern half of the northern "V" of the Whittlesey beach.

0.3 31.9 Turn left (south) from Fulton Co. Road L onto Fulton Co. Road 4. Road cuts diagonally across the Whittlesey beach as it bends back slightly toward the south-southwest. From crest of beach, at south edge of town, an additional Whittlesey beach ridge may be seen ahead to the left (southeast). It might be considered to have been an offshore bar. On the other hand, the land back to the west of the beach ridge under our road is low enough and flat enough to suggest that this main Whittlesey beach might also be an offshore bar here. Actually, many of the beach ridges observed in northwestern Ohio, both north and south of the old embayment, were probably offshore bars, rather than attached bars, because the land submerged by the ice-dammed waters was so very flat, most of it being lake bottom from a still earlier glacial lake, that even small lake waves broke offshore.

0.7 32.6 Turn right (west) onto Fulton Co. Road K (Old State Line Road). Note sand pit back to left in outer Whittlesey beach ridge. Road climbs main Whittlesey beach ridge.

0.3 32.9 <u>STOP 4</u>. Whittlesey beach ridge, at road intersection.

Location: 3 miles northwest of Swanton; NE 1/4 of NE 1/4 of Sec. 33, T8N, R8E, Fulton Twp., Fulton Co.

Small cut in Whittlesey beach ridges exposes typical nature of sand composing most beaches in the Lucas-Fulton County (Oak Openings) area. The place near Defiance where the two "V's" of the Whittlesey beach come together is about 30 miles to the southwest. The Maumee beach, which forms a similar but small V to the north of the same spot, lies only about three miles away to the west of this stop. Eight miles west of here is the edge of the Defiance end moraine itself. In this part of Ohio, the moraine is oriented almost north-south. To the north, it extends into Michigan but, to the south, it ceases to have morainic topography a few miles south of Wauseon near the southern edge of Fulton County. From here south to a point north of Ottawa in Putnam County, the position of the moraine is recorded only by a very low, broad, smooth swell with the Whittlesey beach along its margins. The moraine is smooth because it was submerged, in this segment, by the earlier Lake Maumee. Beaches of this lake, which will not be seen on this trip, outline the areas of morainic topography north of Wauseon and southeast of the point north of Ottawa.

Turn left (south) off Fulton Co. Road K onto Fulton Co. Road 4, which lies on the Whittlesey beach for more than half a mile.

1.0 33.9 Turn right (west) off Fulton Co. Road 4 onto Fulton Co. Road J.

0.3 34.2 Road rises up onto Whittlesey beach ridge again.

0.7 34.9 Turn left (south) off Fulton Co. Road J on to Fulton Co. Road 5. Whittlesey beach is in two parts here, one section lying west of this intersection (under farm with silos ahead), the other section, which we crossed half a mile back, now being present south of this intersection.

0.3 35.2 Cross over Ohio Turnpike.

0.3 35.5 Climb up onto outer section of Whittlesey beach and turn right (west) on Fulton Co. Road HJ off Fulton Co. Road 5. Road follows Whittlese beach ridge. Note old sand pit to left (south) and, ahead, a cemetary on the beach - early grave diggers were generally very careful about locating their cemetaries on beach ridges.

0.6 36.1 Stop. Turn left (south) off Fulton Co. Road HJ onto Fulton Co. Road 5-2. Road crosses over outer crest of Whittlesey beach for the last time. Note continuation of beach ridge off to right (west). Compare beach ridge topography with very flat lake bottom visible ahead (and to be seen throughout most of the rest of the trip).

1.2 37.3 Railroad crossing.

0.1 37.4 Stop. Turn left (east) onto heavily travelled Ohio 2 - US 20 Alt. off Fulton Co. Road 5-2. Road lies on flat Whittlesey lake bottom.

3.3 40.7 Low ridges mark position of Warren beach.

0.4 41.1 Corporation limits of Swanton.

0.3 41.4 Traffic light. Continue straight ahead (east) on Ohio 2 - US 20 Alt. Main part of town of Swanton lies half a mile to left (north).

0.2 41.6 Fulton-Lucas County line.

0.5 42.1 Turn right (south) off Ohio route 2 - US 20 Alt. onto Ohio route 64.

0.5	42.6	Entering Oak Openings Park of the Toledo Metropolitan Park System. The Toledo Metropolitan Parks own only a small part of the Oak Openings area (see Fig. 10), but they have a lovely park about 25 miles long and 5 miles wide within the Oak Openings area which has been tastefully developed. This is the largest of their 7 parks (they also own Farnsworth Park in Waterville, where we will eat lunch). Signs a mile ahead and about 5 miles ahead provide direction to the developed areas of the Park.
0.4	43.0	Swanton City Waterworks on right (west).
2.6	45.6	Turn left (east) onto Waterville-Swanton Road off Providence-Neapolis-Sherman Road, following Ohio route 64.
0.9	46.5	Whitehouse fire tower (Ohio Division of Forestry) ahead on left in Maumee State Forest.
1.4	47.9	Low sand rises here are part of Wayne beach.
0.5	48.4	Pits in low sand hills to right are in Wayne beach. This is the last true beach deposit to be seen on this trip; all the rest of the area will lie on flat lake bottom.
0.4	48.8	City limits of Whitehouse. Follow Ohio route 64 through town, turning right (south) at stop sign and left (east) at yellow blinker.
1.0	49.8	Small quarry to left (north) and larger quarry to right (south), now abandoned, are probably in Bass Islands dolomite.
1.8	51.6	Half a mile to south, at low rise, is small abandoned quarry in Sylvania sandstone.
0.2	51.8	Notice extreme flatness of land, and dark brown to black color of soils in this area. This is characteristic of the areain northwestern Ohio once called the Black Swamp. The Black Swamp occupied a broad belt, 20 to 40 miles wide, south of the Maumee River and extended for over 100 miles from Lake Erie to Indiana (see Fig. 10).

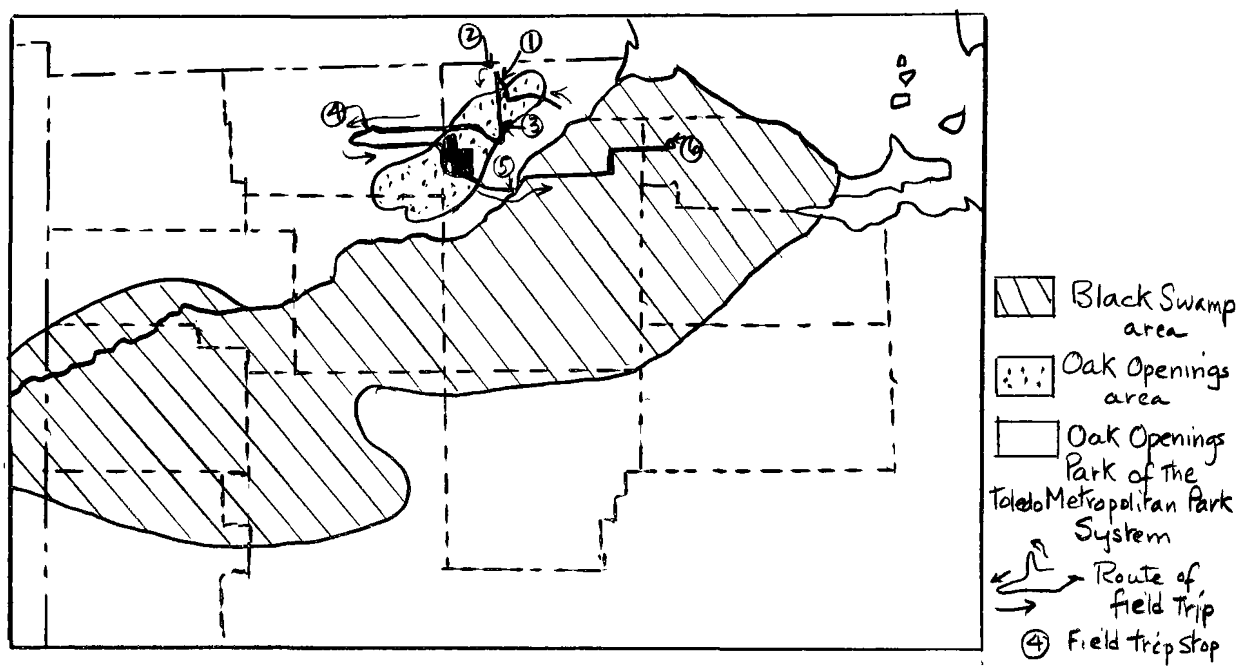


Figure 10. Map of northwestern Ohio showing location of Black Swamp, Oak Openings and Oak Openings Park of the Toledo Metropolitan Park System

It represents the low, flat lake bottom area of that region, where clay rather than sand accumulated (where the sand is present, north of the Maumee River, is the area of the Oak Openings). Because this broad area of land is so very flat and lacking in natural drainage and the soil is so clay-rich, this area formed an almost impenetrable swamp before extensive drainage ditches were put in, in the 1870's. Before that time it was the most formidable barrier to transportation in all Ohio! It was described by early writers as: "troublesome marshes where no bit of dry land was to be seen, and the horses at every step wading in the marsh up to their knees"; "thirty-five mile trip from the Sandusky to the Maumee had taken....two and a half days"(by horse-back); "man and horse had to travel mid leg deep in mud" and "the mud was ancle deep in our tents" (quoted from letters by members of General Hull's army); a"fearful morass"; a "hideous swamp"; "mud from knee to belly deep to our horses for 8 to 10 miles together" so that "the labor of travelling is almost intolerable to the horse and rider"(quotes from quotations in excellent survey of history and effects on Ohio history of Black Swamp by Kaatz in Annals of the Assoc. of Amer. Geographers, Vol. XLV, March 1955, pp. 1-35).

1.4 53.2 Waterville city limits. Stay on Ohio route 64.

0.8 54.0 At diagonal intersection, follow Ohio route 64 almost straight ahead (southeast) from Michigan Avenue onto Farnsworth Road.

0.1 54.1 Traffic light. Turn right (southwest) onto US 24.

0.6 54.6 Hummock to right is dump from Waterville quarry of France Stone Company, which is located north of US 24.

0.6 55.2 Turn left into one of two parking areas of Farnsworth Park for LUNCH.

After lunch, turn right (northeast) out of Farnsworth Park parking areas onto US 24.

0.1 55.3 Turn right into field beside road and park, arranging cars so that there will be room for all of them to be off the road.

<u>STOP 5</u>. Wood County or Bowling Green fault in Tymochtee dolomite, opposite Woodville quarry.
Location: 1 mile southwest of Waterville; west end of Sec. 39 (narrow east-west section), T1, Waterville Twp., Lucas Co.

The Wood County or Bowling Green fault here is the extension to the south of the Lucas County monocline on which all three of the earlier quarries visited (Stops 1, 2, and 3) are located (see map, Fig. 11, on next page), copied from D.W. Farnsworth). This fault trends north-south, is almost vertical (the fault plane dips 80°toward N 70° E), and has a maximum throw of over 200 feet. It cuts diagonally across the western part of the Findlay arch (northern extension of the Cincinnati arch). It may be traced (by well records; this is the only area where it can be observed at the surface) from 6 to 8 miles north of Waterville south for about 40 miles, to as far as a point between Findlay and Arlington in southern Hancock County. It should probably be actually called a fault zone, since several individual fault planes are often present and, in places, these fault lines seem to have an en echelon arrangement. Here on the bank of the Maumee River, although Tymochtee dolomite (Bass Islands Group) lies on both sides of the fault line, more than 200 feet of throw is recognized (based on the zones identified in the Tymochtee).

All specific information about the fault presented here has been provided by Don Farnsworth, who has made a detailed study of the rocks of the central (this) part of northwestern Ohio, and whose report will be published by the Ohio Geological Survey.

Continue ahead (east) on right-hand road of "Y". Note Tymochtee dolomite exposed ahead to left and also in the river bed to right (visible only if water is low).

1.3 56.6 At second red light in town of Waterville, turn right (east) onto Ohio route 64 again. Road crosses Maumee River, here floored with Tymochtee dolomite, and Lucas-Wood county line.

0.4 57.0 Turn left (north) off Ohio route 64 onto Ohio route 65.

0.5 57.5 Turn right (east) onto Five-point Road. Route will continue east on this road for about 10 miles, crossing two major highways, and always lying on the flat, flat lake bottom (which in most places is characterized by a few feet of lake sediments over till, but in places is composed of till only, despite the smoothness of the surface).

3.5 61.0 Stop. Continue straight ahead (east) across heavily travelled US 25.

2.5 63.5 Stop. Continue straight ahead (east) across US 23 at 5-way intersection.

1.4 64.9 Stop. Continue straight ahead (east) across Lime City Road. Note small quarry in Bass Islands dolomite (Greenfield)? to right (south) side of road.

2.0 66.9 Jog left (north) on Tracy Road and then right (east again), still on Five-point Road.

1.0 67.9 Turn left (north) onto Stony Ridge Road.

0.2 68.1 Turn right (east) onto heavily travelled US 20 in Stony Ridge.

0.2 68.3 Cross railroad tracks in Stony Ridge. Rise ahead is supported by bedrock, probably Bass Islands (Greenfield). Throughout this Lucas-Wood County area, where there are large quarries in Guelph dolomite, it has been observed by Dr. Carman that the quarries are generally on bedrock rises, that the Guelph dolomite in the quarries is generally overlain by a thin cap of Greenfield dolomite, yet that, in the lower areas between the "highs", where bedrock is exposed, that it is the Greenfield dolomite which is observed. It seems that the topographic rises, which appear to represent highs on the bedrock surface, might also represent high spots on the Guelph-Greenfield (Niagaran-Cayugan) disconformable contact also? Might this be due to reef or reefoid structures? This apparent situation is illustrated in Figure 12. (Observations and thinking quoted from notes

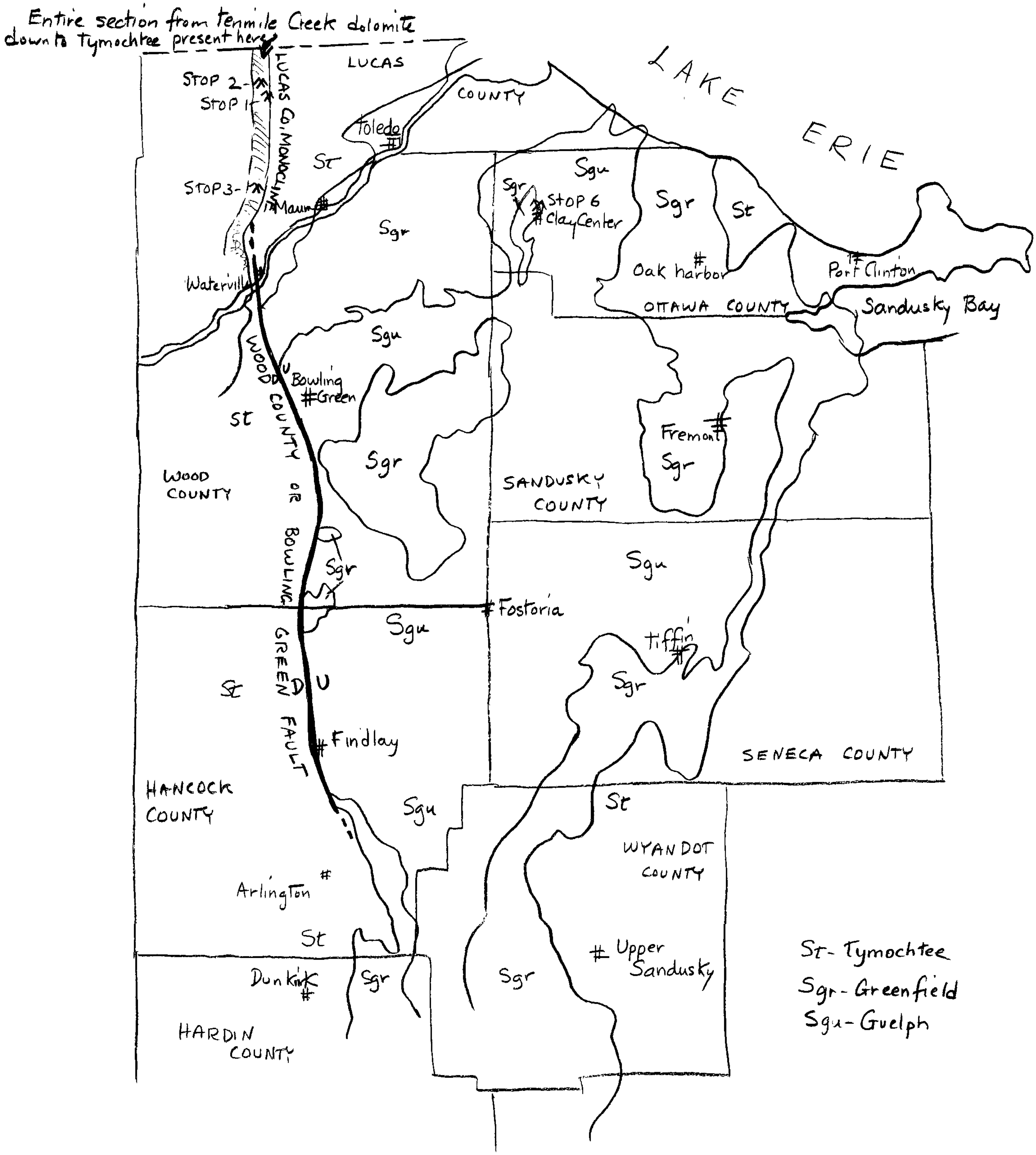


Figure 11. Map showing the location of the Lucas County monocline and the Wood County or Bowling Green fault Information on the monocline taken from information by Dr. Carman; information on the fault and subsurface geology provided by D.W. Farnsworth

from Dr. Carman's class).

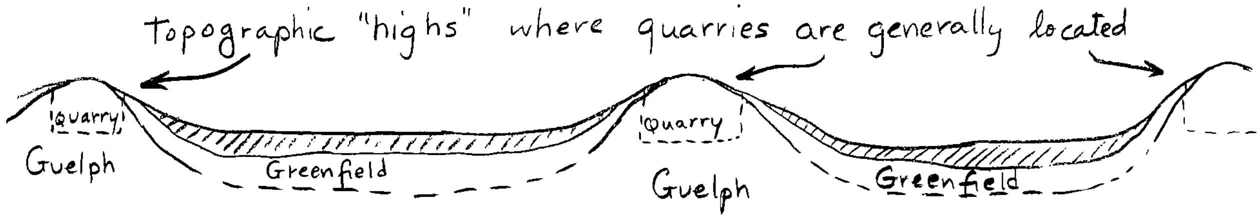


Figure 12. Diagram illustrating probable relationship of Greenfield-Guelph contact and topographic surface, from field observations

0.3	68.6	Turn left (northeast) off US 20 onto Ohio route 163 beyond second church on left. Road lies on bedrock high.
0.2	68.8	Rock is exposed at surface by drive in Boy Scout camp to left (west). Note abundant boulders in this area, especially in woods farther along, to right; work by Lois Campbell (1955, unpublished PhD dissertation for OSU) shows that boulders are generally common in areas where bedrock is shallow in this glacial lake country.
0.4	69.2	Note rock exposed along road ditch to right and also abundant boulders here. Stop. Turn right (east) following Ohio route 163. Note more rock exposures and abundant boulders.
0.3	69.5	Turn left (north) off Ohio route 163 onto Luckey Road. Roads lies mostly on flat lake bottom land, but another small rise, prbbably produced by a rise in the underlying bedrock, is crossed by the road about a mile ahead.
1.5	71.0	Cross over Ohio Turnpike. Ditches along road north of this crossing exposedtill capped by a foot or so of lake clay in March; this stratigraphy should still be visible.
1.5	72.5	Turn right (east) off Luckey Road onto Ohio route 795. Road crosses southern end of Walbridge yard of the C&O railroad and then passes south of old Toledo airport. Route continues east on this road for about 7 miles.
1.7	74.2	Traffic light. Continue straight ahead (east) on Ohio route 795.
1.3	75.5	City limits of Millbury.
1.0	76.5	Jog left (north) on Martin Road and right (east) on county line (Wood-Ottawa) or Fostoria Road (east).
0.8	77.3	Stop. Continue straight ahead (east) on Ottawa Co. Road 66 (also called Moline Road and Martin Road on map).
2.2	79.5	Stop. Turn left (north) off Ottawa Co. Road 66 onto Ottawa Co. Road 51. Pass corporation limits of town of Clay Center, which is ahead to left, and then cross bumpy railroad crossing.
0.4	79.9	White Rock Quarry of Basic Incorporated at Clay Center to left. Note that flat lake bottom land surface to right gives no clue to presence of bedrock so close to surface here.
0.8	80.7	Turn left (west) off Ottawa Co. Road 51 onto unnamed cement road, at corporation limits of Clay Center. Road goes along north edge of quarry and affords a good view of south end of quarry bottom and of quarry buildings.
0.5	81.2	Follow cement road to left (south).
0.2	81.4	Park on left, close together and leaving room for other cars to pass.

STOP 6a. White Rock Quarry of Basic Refractories Inc. at Clay Center - Surface level.
Location: at north edge of Clay Center; SW 1/4 of SE 1/4 of Sec. 9, T7N, R 13 E, Allen Twp, Ottawa Co.

This stop at the surface level of the quarry is for the purpose of seeing:

1. the nature of the overlying till (no lake sediments here, despite the location on the Elkton lake bottom!) and the soil (Hoytville clay , and Millsdate silty clay loam where the rock is within 3 1/2 feet of the surface) developed in it;
2. the base of the Greenfield dolomite (basal Bass Islands Group) where here contains zones which contain abundant fossils (but of few genera - Leperditia, Hindella);
3. the disconformable contact of the Cayugan Greenfield dolomite on the Niagaran Guelph, marked in places here by a thin (few inches) band of hard green clay, claimed by some to be a reworked residual clay or soil of Salina age;
4. a good view of the quarry itself.

Continue straight ahead and, at road junction in a few hundred feet, turn left (south), again at corporation limits of Clay Center.

0.4 81.8 Turn left (east) into Clay Center quarry ground and follow lead car around buildings and down into quarry for final stop.

STOP 6b White Rock Quarry of Basic Refractories Inc. at Clay Center - quarry floor level.
Location: same as Stop 6a.

Except for near the surface, where the Greenfield dolomite was just observed, all the quarry is in Niagaran Guelph dolomite. Lithologic variations occur in color (white to blue-gray and brown, with some petroliferous staining), porosity, crystallinity (small sugary grains to large recrystallized grains to massive poorly porous rock), and abundance of fossils. Locally bedding is lost and abundant fossils suggest the presence of a possible bioherm or biostrom; however, this interpretation is open to question because stromatoporids (the main reef-builders of that time) are not always present. No certain reef structures have been observed in this quarry, but in places peculiar features suggest this explanation. The group will have a chance to observe and argue about one of these. There is also excellent fossil and mineral collecting in this quarry. Minerals most commonly found are: calcite, dolomite, fluorite, pyrite, sphalerite, and celestite. Fossils found in this formation include: Stromatopora, Favosites, Halysites, Syringopora, Trimerella, Megalomus, and Tremanotus. Feel free to collect anywhere around the quarry, but DO NOT DRIVE around on the quarry floor; walk!

This is the last stop of the 1962 field trip. We hope that you have enjoyed it, and will look forward to seeing you at the meetings a year from now.

To get back to civilization:

1. going west, go south from quarry entrance to first road south of railroad crossing; go west on this road (our route earlier) to Ohio route 795 for Maumee or west and south to Ohio Turnpike via Interstate 280.
2. going east, go south on road west of quarry entrance to Woodville on US 20 or follow directions above for Ohio Turnpike.
3. going south, go south to Woodville and US 20 for connections to US 23 and US 25.

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